

Expressive Structures

Exploring Architectural Design Through Engineering Principles

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Architecture and Urban Design

Building design and transformation

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Figure 1 (Cover). Skyline of sports hall.

Abstract

This thesis investigated the intersection of architecture and engineering with a focus on the role of structures in shaping space, order and character of buildings. The research aimed to explore how structures can influence the character of the architectural language of a building.

Usually structures are seen as a necessity rather than potential, and are often designed around efficiency and compromised solutions between architects and engineers. The question that arises from this perspective is, how can a tectonic approach be used to design a multipurpose sports hall in Gothenburg?

By engaging with both theoretical discourse and design experimentation, a design task was set to create a sports hall for Chalmers campus which became a testing ground for the thesis topic.

The research found that by engaging with design and engineering of structures, one can make use of the logic there is behind the natural perception of the structures to deliver a message about spaces and elements that align with the architectural intention and expression of the building.

The research further allows the investigation to be discussed from a more holistic approach to ensure that the terms between engineering and architecture can merge into a single unified expression.

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Introduction

Background

"There can be structure without architecture, as in any machine, but no architecture without structure. There can be aesthetics without architecture, as in any painting, but no architecture without aesthetics. But is there an influence of structure on aesthetics?" (p.288) (Salvadori, 2002)

To sustain a space for activities there often needs to be a structure which can envelope space and shelter. Now this structure can work in different ways and have different degrees of exposure. In some buildings the structure remains a silent, almost non visible element as that is not the architect's intention with the character of the building. In other cases the structure is the main element for the character of the building, it can be

to the degree where no other layers are needed to fulfill the architect's aesthetic intention. But it is important to distinguish between a structure that is responsible for the building's aesthetic look, and for structures that only work as a machine.

The theme is both interesting and significant for the field and for the overall quality of architecture, since it enables yet another tool for the architect to explore ideas and concepts to create meaningful coherent building designs. Therefore architects should be aware of the potential that structures carry in ordering space and creating experiences. This enhances their ability to work with the structure rather than alienating the elements.

Aim & Research question

The aim of this thesis is to understand how structures as a visible element can order space and align with architectural design intentions. As an exploration, a design task of a multi purpose sports hall will be used as a testing ground for the theme to be further explored.

How can a tectonic design approach be used to design a multipurpose sports hall in Gothenburg?

Delimitations

The thesis does not focus on the structural efficiency, ecological imprint or economical factors of the load bearing systems, it instead considers generalised solutions. The generalised solutions are supported from both literature studies and reference projects. This keeps the scope of the thesis around the potential of structures as an architectural driver rather than trying to solve a technical and quantitative problem.

As for the programme of the design task, the thesis does not consider the idea from an entrepreneurial perspective, as this would require a much broader investigation.

Method

Investigating theories and projects

To gain an understanding of the theme around building tectonics, analytical reading was done on writings that address philosophical questions related to the theme. The writings included an explanation of views and reasoning behind the approach in architectural design.

An examination was done on built projects where structure plays a visually expressive role. These studies provided a comparative ground for evaluating how the approach informs space and experience.

A cycle of iteration

Although the theoretical foundation was established before the design phase began, it was important to allow room for continued theoretical analysis throughout the design process. A method that was used in the design phase included a cycle of research by design together with an

interdisciplinary method of iteration and critical review. Such a process helped connect insights from both theory and practice, strengthening the project's conceptual coherence and clarifying design decisions.

Different modes of production

The iterative design process employs multiple modes of creation, including physical and digital modeling, sketching, and image production. These methods serve both as tools for exploration such as testing structural and spatial ideas but also

as means of communication, allowing the design outcomes and their theoretical connections to be visualized and evaluated effectively. (Hanington & Martin, 2019)

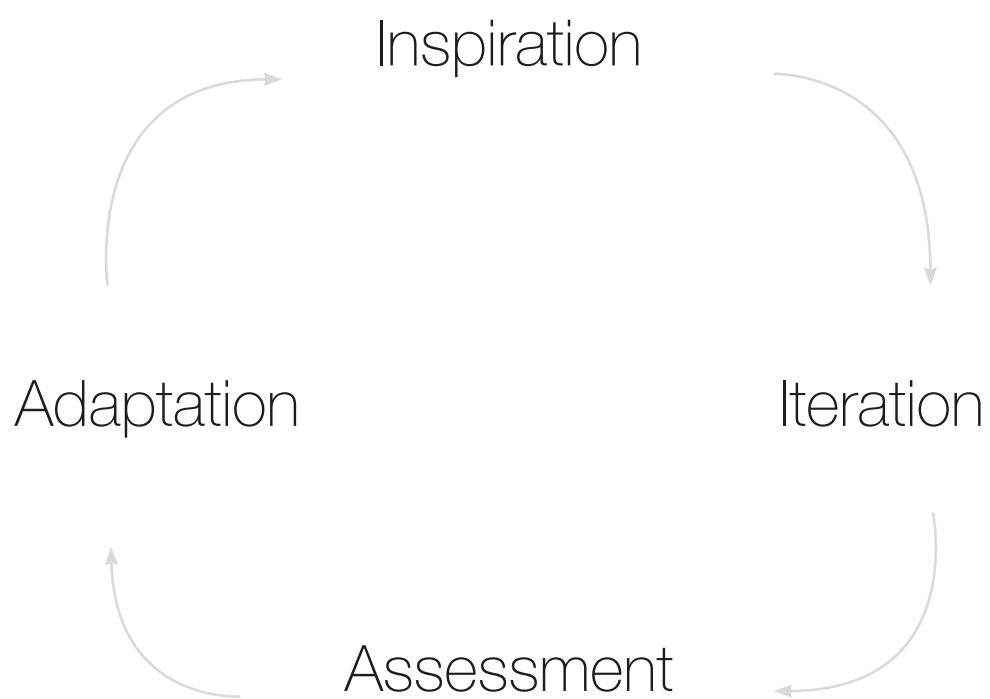


Figure 2. Cycle of iteration

Theory

Perception and intuition of structures and space

The way humans perceive objects and our environment can be understood as a relationship shaped by expectations that arise from individual experiences, understandings, references, and personal logic. However, despite these subjective differences, there are often shared foundations in how people interpret what they see, and this extends to the perception of architecture.

An underlying intuition informs our understanding of form and material. This intuition is largely built upon accumulated knowledge and personal experience related to space and matter. Because most people have, to some extent, been exposed to these visual and physical realities in everyday life, they develop a general sense of what forms appear stable, what materials seem appropriate for certain uses, and what spatial configurations feel feasible. In this way, our collective and individual experiences together shape how we intuitively read and judge architecture. This is discussed by Popovic where she outlines the concrete reasons behind understanding structural integrity. (Popović Larsen et al., 2003)

"Being constantly exposed to concepts that "work" helps us develop a "feel" for what is right and intuitively we are able to tell, often without knowing why, that some structures are better than others." (p.17)

However, it is worth noting that not all buildings use structure to express a language beyond mere structural integrity. In the eyes of some critics and theorists, such architecture can be

perceived as incomplete, lacking the expressive or narrative dimension that emerges when structure contributes to the architectural language itself. (Saint, 2007)

Some perceive the aesthetic element as only a driver for architectural beauty but not as a necessity. This is explained by Salvadori:

"It is easy to prove that aesthetically satisfying buildings can be designed even if structural laws are totally or partially ignored. For example, the conversion of a wooden temple into a stone structure led the Greeks to the creation of one of the masterpieces of architecture, the Parthenon (Fig. 17.1), though judged from a purely structural viewpoint the Parthenon is anything but "correct." On the other hand, some engineers have preached that one can ignore aesthetics because, if a building is correctly designed structurally, beauty will shine from the correctness of the structure. The innumerable examples of "correct" structures which many consider ugly (Fig. 17.2) disprove this theory. Engineers like Nervi or Maillart have designed aesthetically wonderful structures because their innate feeling for beauty guided them even beyond their structural genius (Fig. 17.3)." (p.288-289)

Salvadori further explains that the Parthenon is not "correct" because the new stone element resulted in a major increase in pillar thickness in order to reduce the span of the new stone beams. (Salvadori, 2002)



Figure 3. Balanced stones. (Sebastian Delmont, 2012). CC-BY-NC-SA 2.0

Palazzetto dello sport - Pier Luigi Nervi & Annibale Vitellozzi

Palazzetto dello sport in Rome is a great example of how structure becomes a driver for the architectural expression of the building. The structure does not shy of claiming the space. The structure also gathers the main function into the center and allows openings in the facade to create an arcade and entries from several directions.

This way of working with the structural elements to be the main dividers of space elevates the buildings confidence and is seen as synergy between structure and architectural ambition.

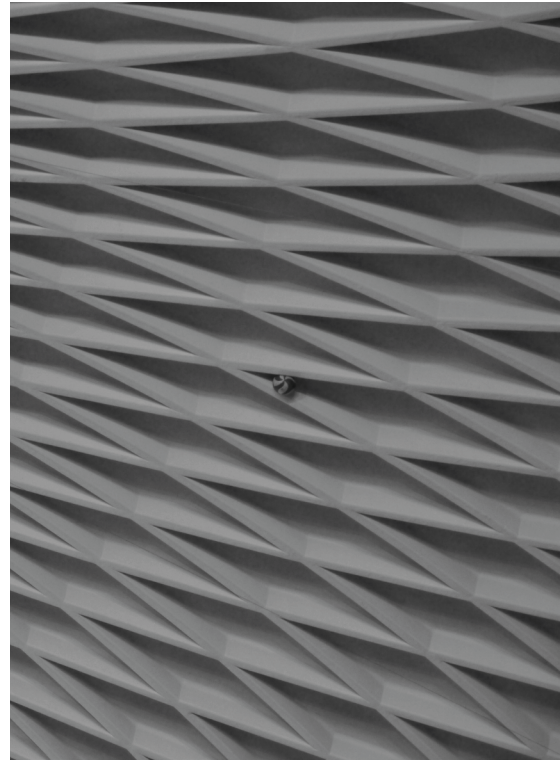


Figure 4 (Top). Ball stuck in the ceiling Palazzetto dello sport. (Absurdicus, 2014). CC-BY-SA 3.0
Figure 5 (Bottom). Outside of Palazzetto dello sport.



Figure 6 (Top). Aerial view of Palazzetto dello sport. (HerRobin, 2024). CC-BY-SA 4.0
 Figure 7 (Bottom). Inside of Palazzetto dello sport. (Dario Crespi, 2025). CC-BY-SA 4.0

Gymnase Jules Ladoumégue - Jean Peccoux & Robert Lourdin

The sports hall from architect Jean Peccoux in Paris uses timber in a brave way to deliver a large space where the experience is beyond the sporting activity. The majestic structure allows itself almost as a sculpture in the middle of the city and yet again deliver itself as a confident building. Along the aesthetics of the structure, the elements frame the sky in yet another aspect to create beautiful scenery from the inside out.

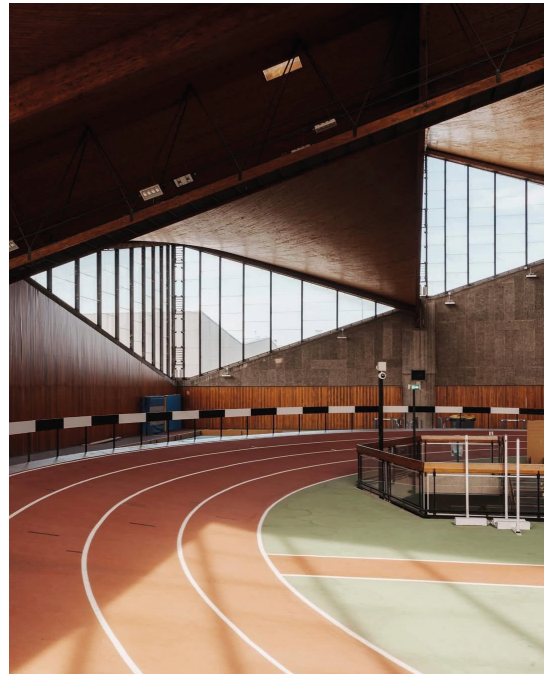
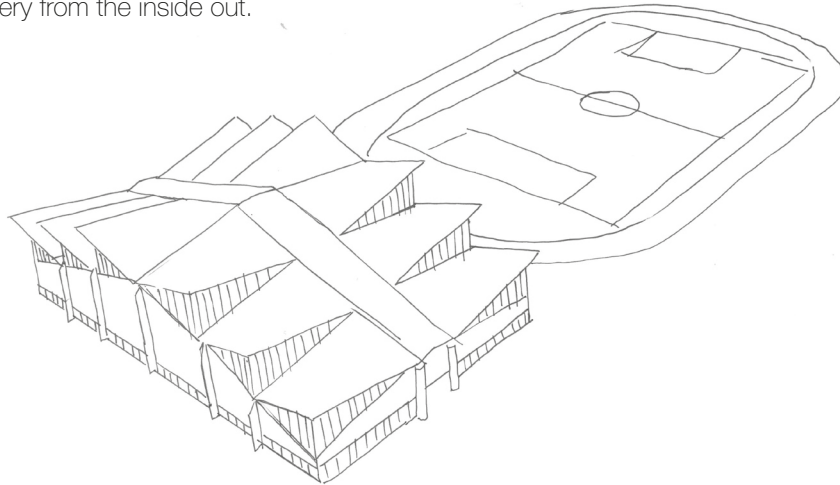


Figure 8 (Photo Gallery). Photos of Gymnase Jules Ladoumégue. (Romain Laprade, 2024). Used with permission



Design task

Programme and ambition

The need for additional sports halls in Gothenburg is evident. As the city grows and demands for recreational and athletic facilities increase, the sports hall emerges as a relevant and timely building typology to explore within an architectural context. Beyond its social importance, the sports hall also provides a suitable scale and programme for investigating structural concepts in depth, making it an ideal case study for a design project concerned with the expressive and functional role of structure.(Nybyggnad och upprustning av idrottshallar, n.d.)

The Chalmers Student Union has developed a long-term vision for the campus, titled Kåren 2040. This vision outlines ambitions for development across several areas, including improved services and digitalisation to support campus operations,

enhanced social integration for new students, and the expansion of the Student Union Building. A key part of this vision also focuses on promoting health, exercise, and social inclusion among students. (KÅREN 2040, n.d.)

Within this context, the thesis will explore the concept of a planned multipurpose sports hall that aligns with Kåren 2040's goals of inclusion, wellbeing, and an enriched campus life. Currently, the campus includes a gym hall of approximately 200 square meters, which no longer meets the diverse needs of the student community. To accommodate a broader range of activities, from sports and physical training to social events and banquets there needs to be a larger and more adaptable facility.

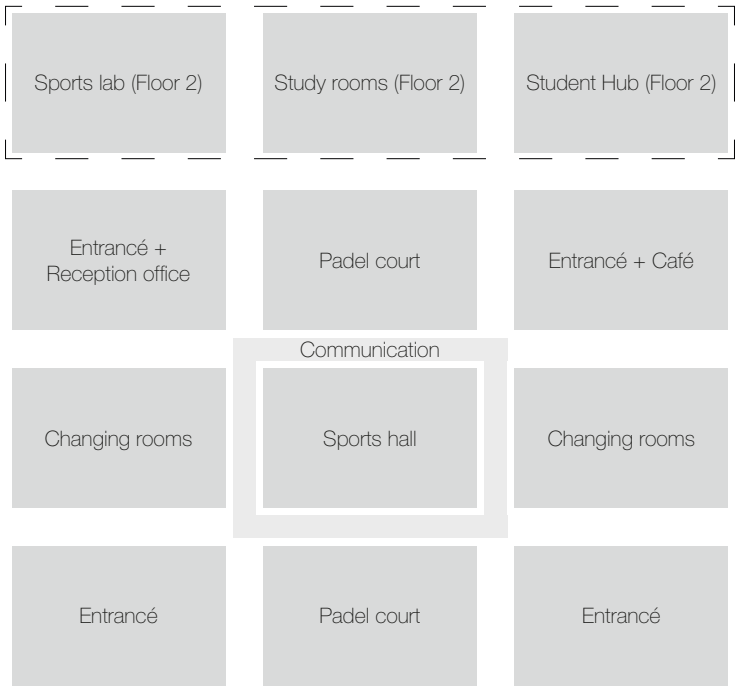


Figure 9. Space programme

- Existing sports facilities
- Future Chalmers sports hall

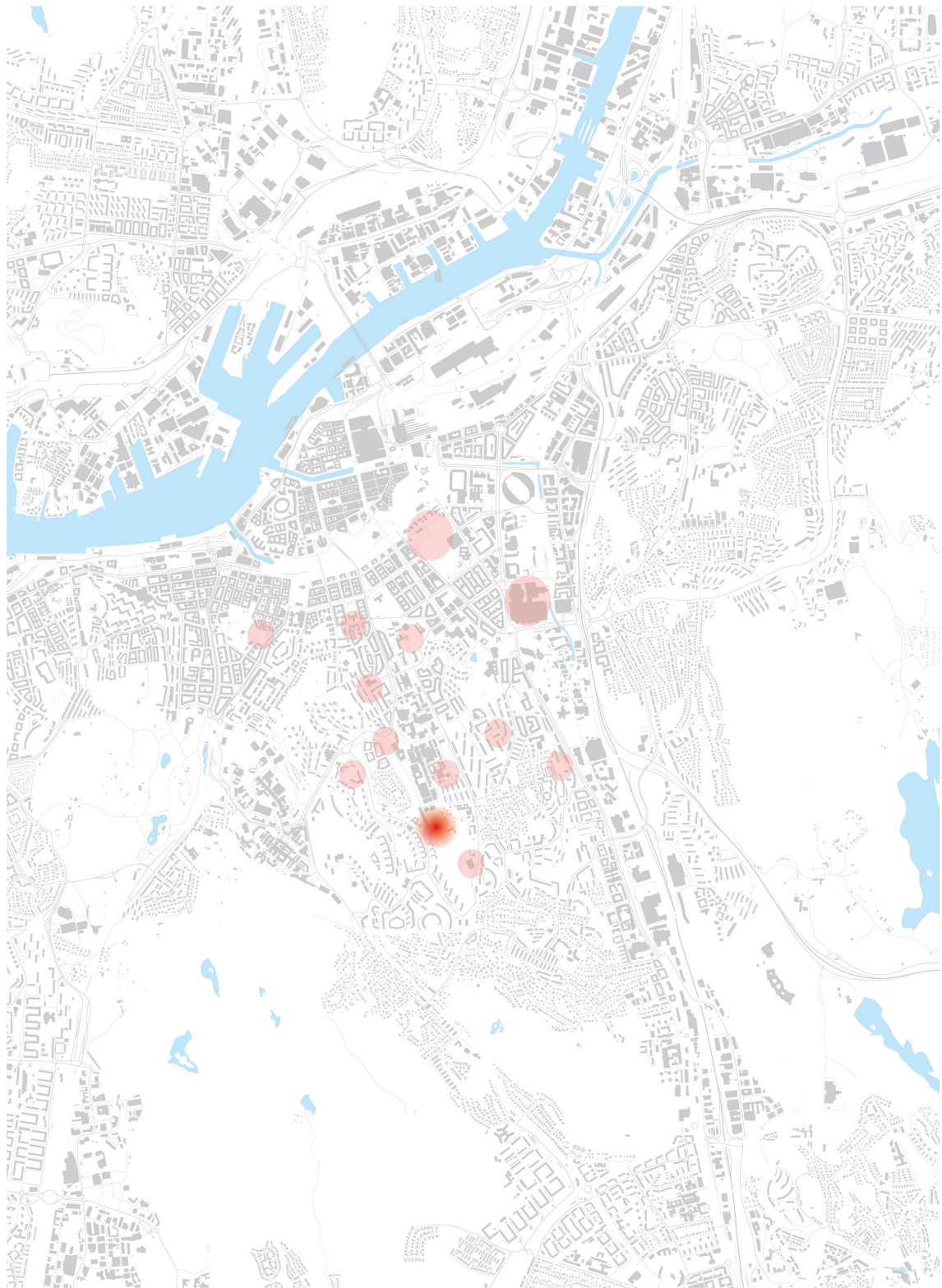


Figure 10. Mapping of sports activities near Chalmers Campus

The site & analysis

In response to this need, the Chalmers Student Union has submitted an inquiry to Göteborgs Stad regarding the possibility of constructing a new multipurpose hall south of the campus, on the site currently occupied by a football pitch. The proposal suggests relocating the pitch further south to make room for the new building, which would be positioned on the northern part of the site, adjacent to Johanneberg Science Park. This location offers opportunities for connection between the student community, the university, and the innovation network of the science park. The program will highlight the importance of adaptability. A sports

hall is rarely a single-purpose space, it must accommodate multiple functions, from organized sporting events to informal gatherings, cultural activities, and community use. Flexibility therefore becomes a key design parameter. To support this, the structural system must be conceived in a way that allows for openness, versatility, and long-term adaptability. The project will thus investigate how structure can be both a functional enabler and an architectural driver, providing a framework that suits the diverse and changing needs of a multipurpose hall while also shaping its spatial and aesthetic qualities.

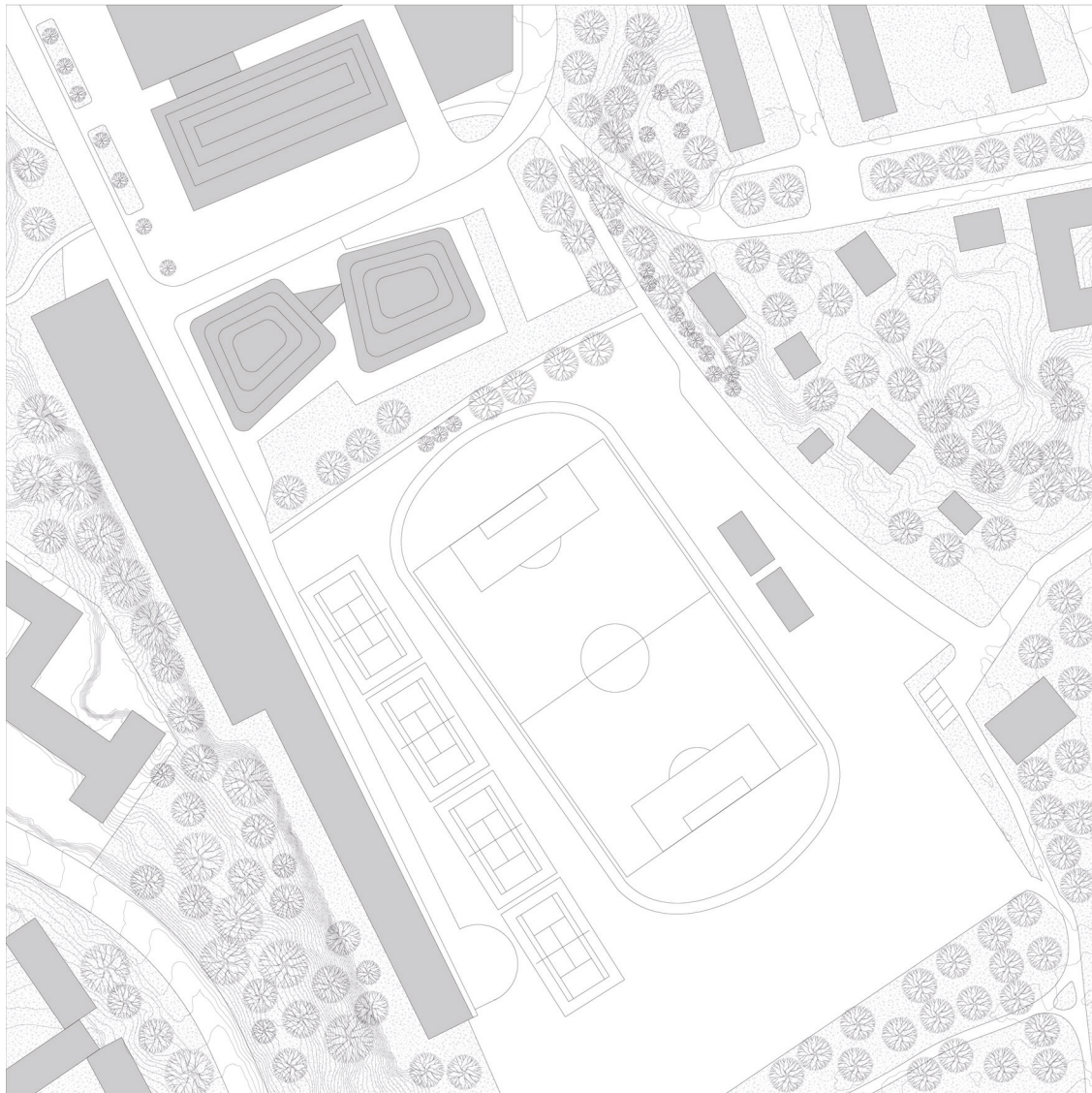
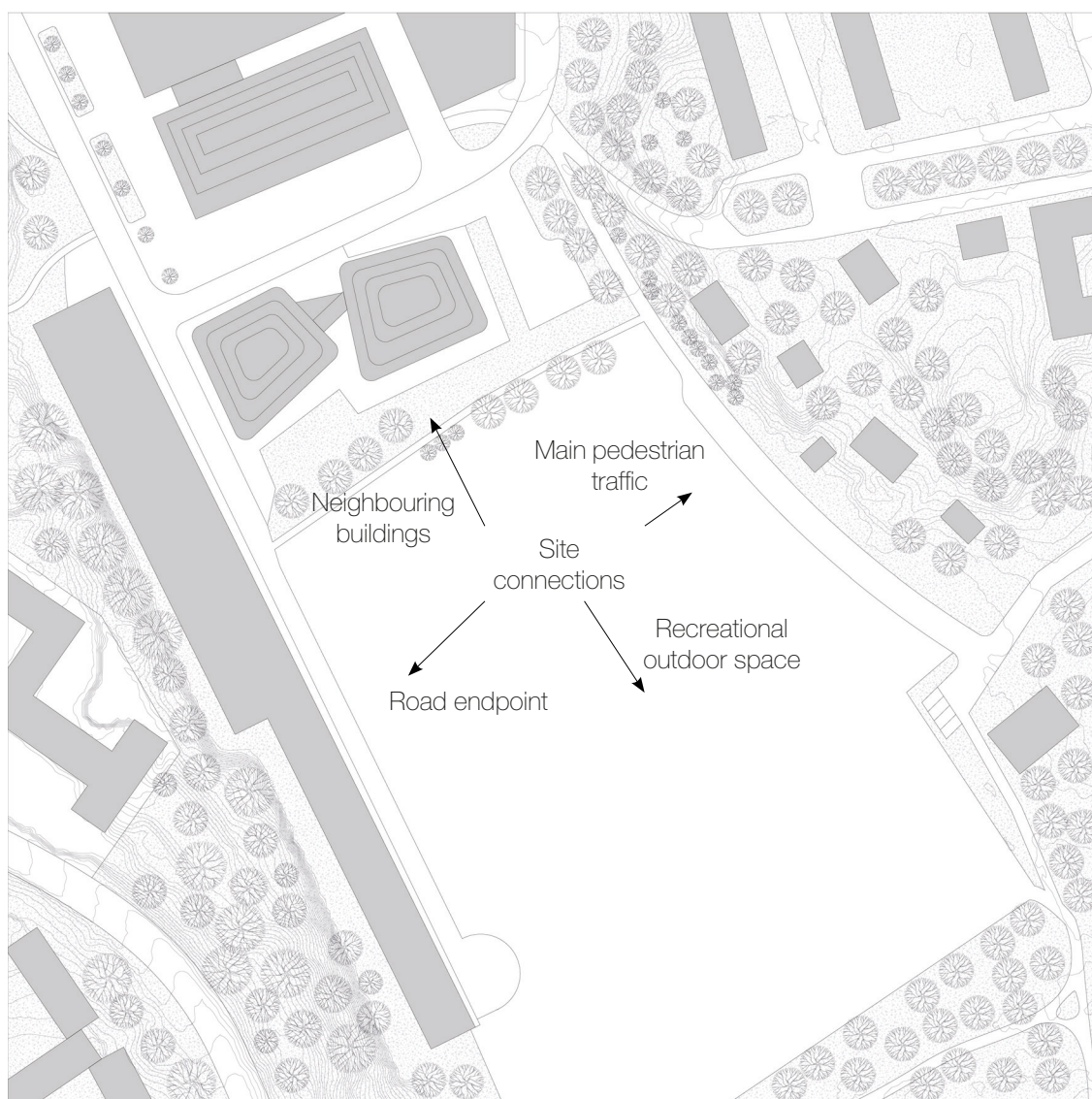


Figure 11. Current situation over site

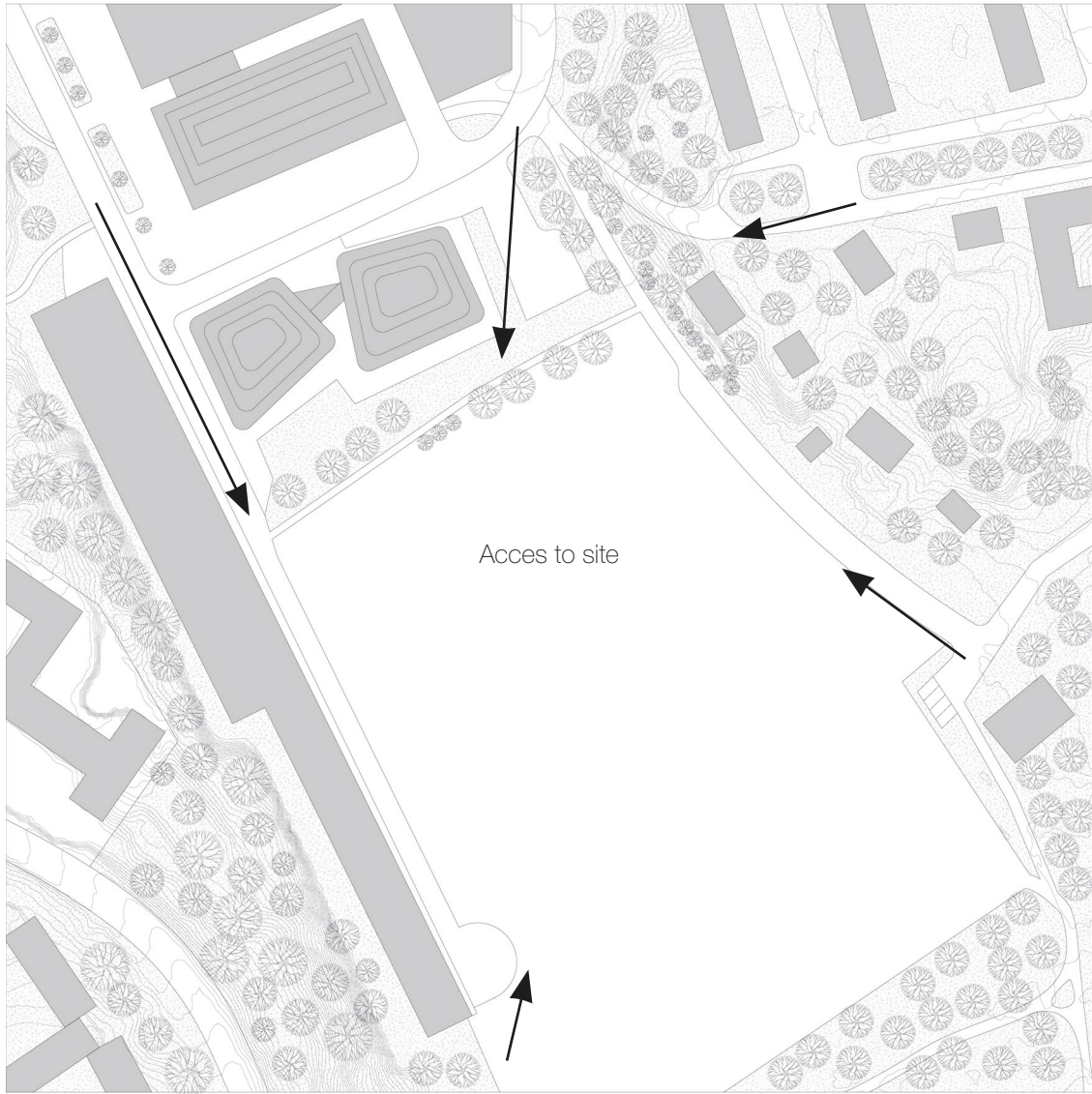


Figure 12. (Photo Gallery). Photos from around the site



1:2000 100 m

Figure 13. Site analysis: Site connections



1:2000 100 m

Figure 14. Site analysis: Access to site

Early ideas

In the beginning of the sketching phase a lot of the ideas were revolving around a bigger volume that is enveloped by different smaller functions. This was a product of the size that the sports hall carries.

Together with an investigation over the structures capacity and the need for bigger trusses and roofs, the ideas started to take shape into both

experimental structural order but also a potential to create interesting spaces below the structure.

Together with aim for natural light and a careful consideration of the sports hall limits of sun rays, the roofs started taking shape with many openings where structure needed to allow for openings and express the building's character with confidence.

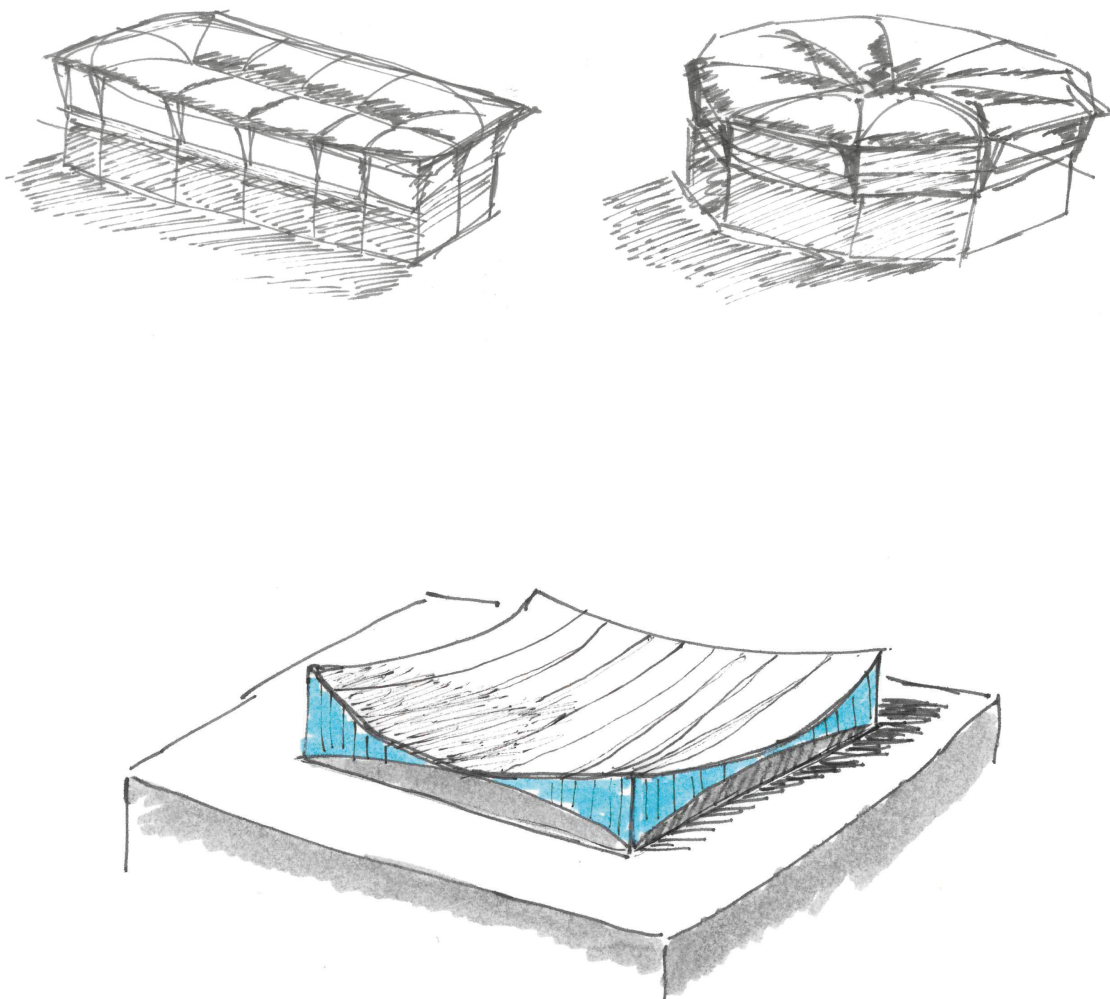
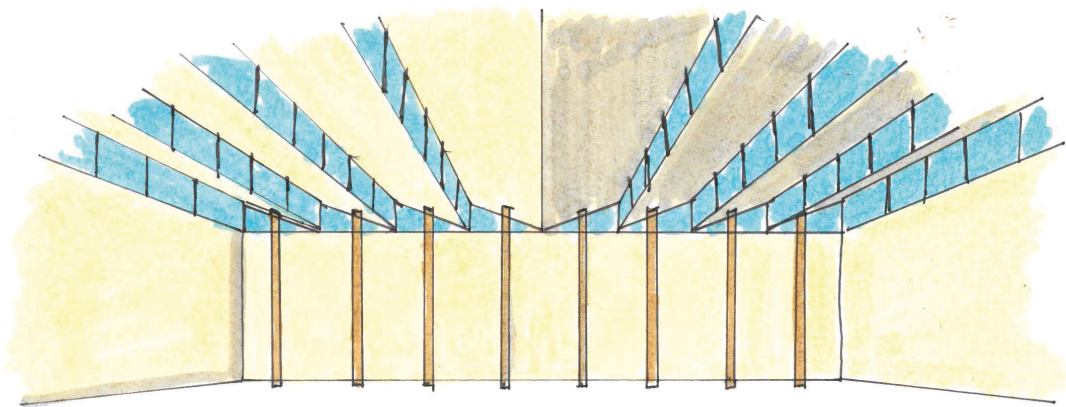
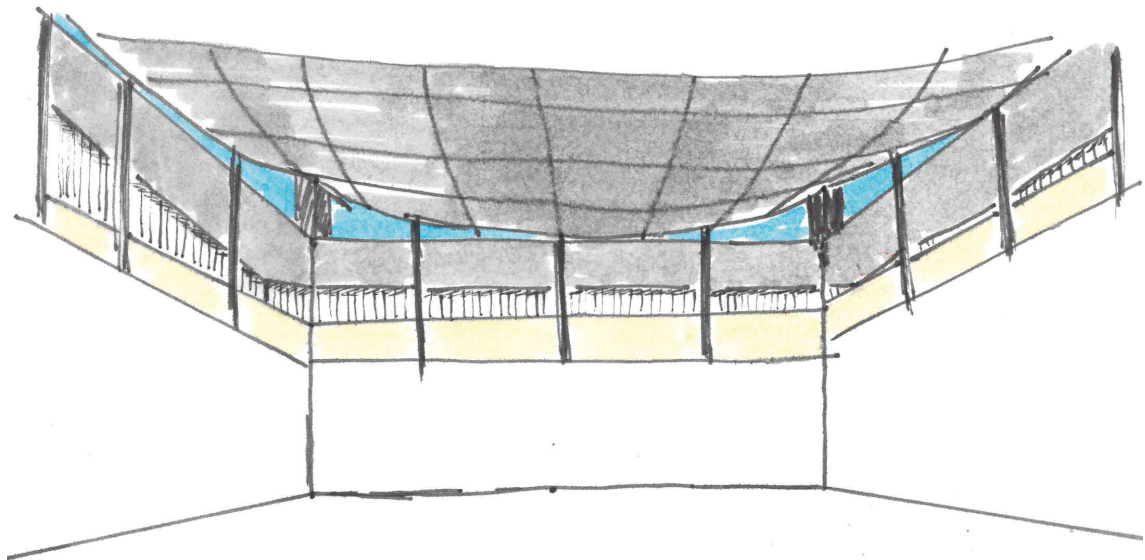
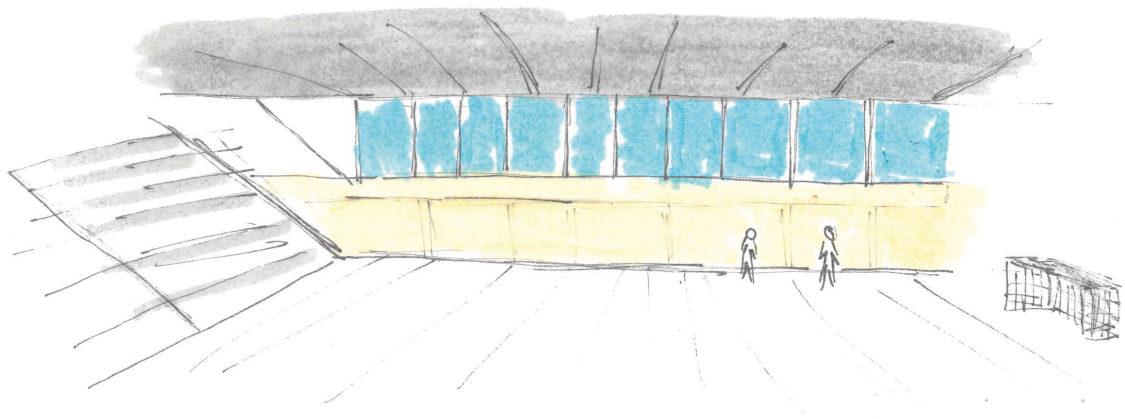
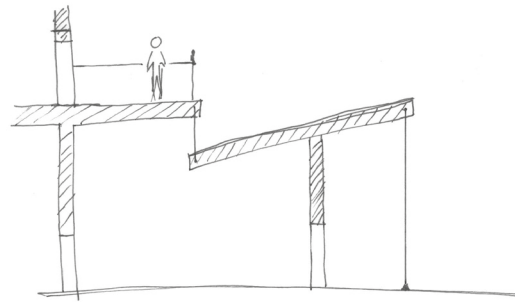
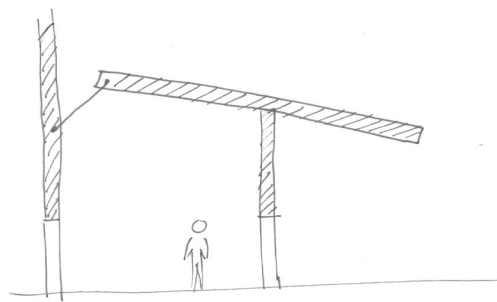
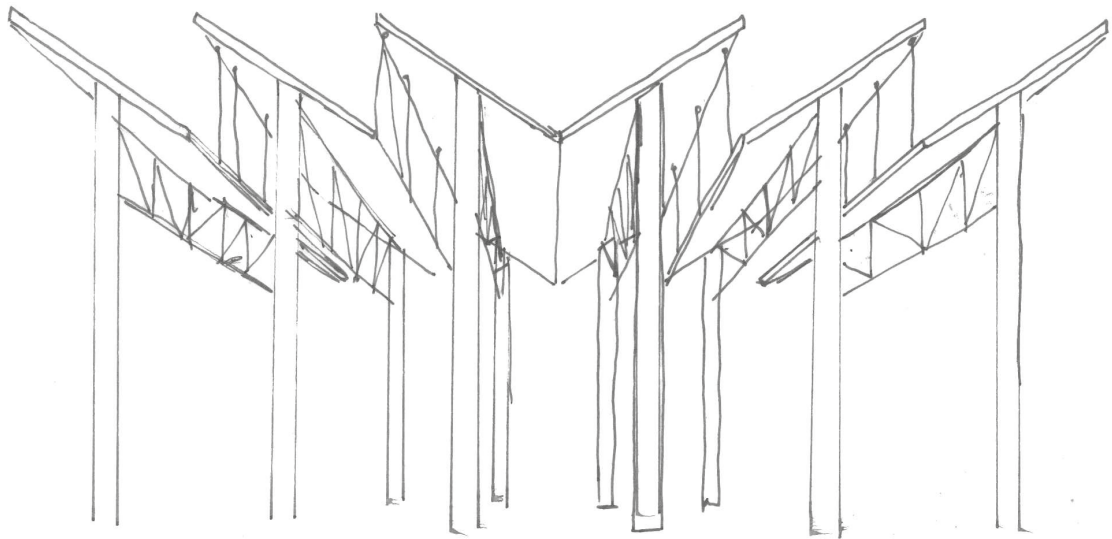
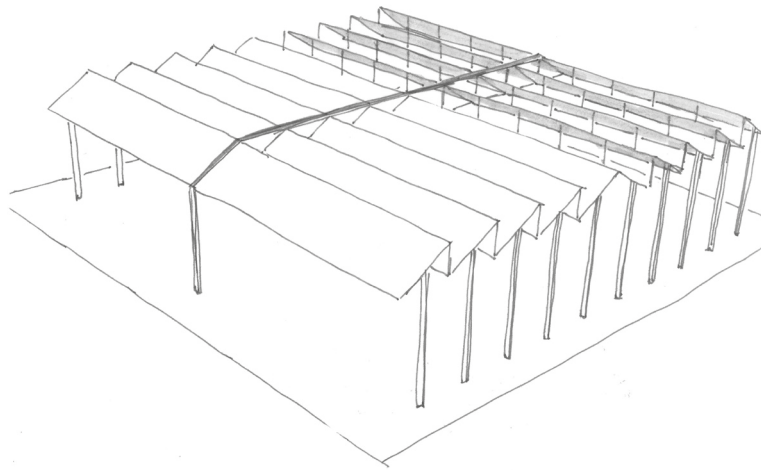


Figure 15 (Gallery). Early sketches of volumes and spaces





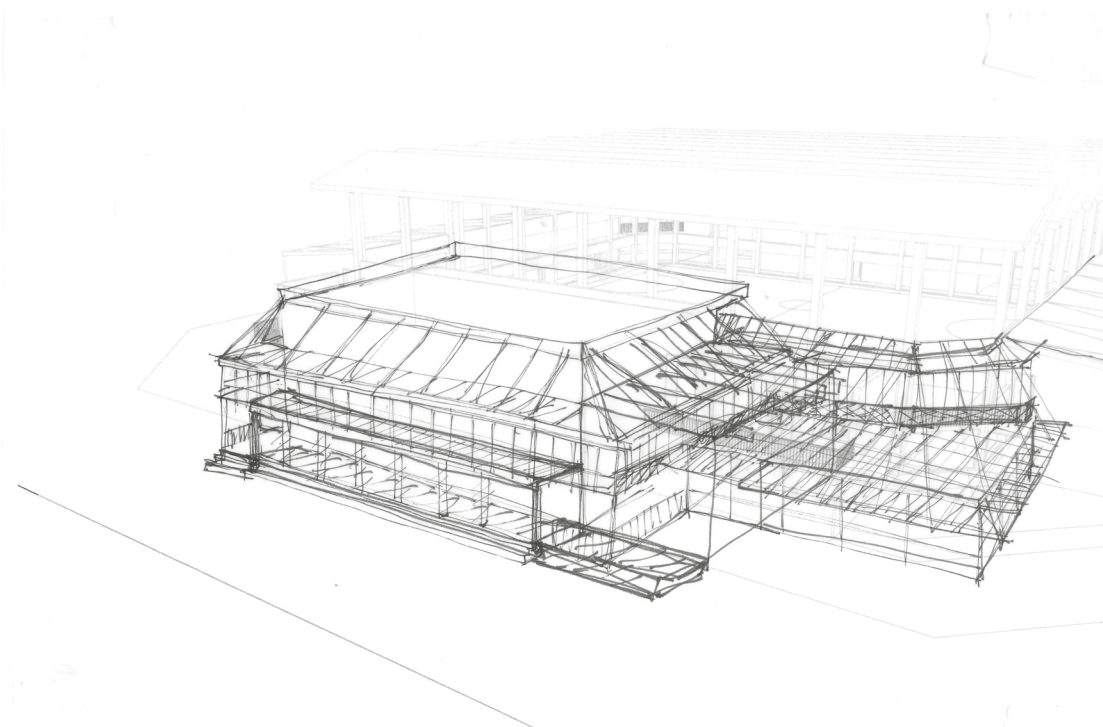
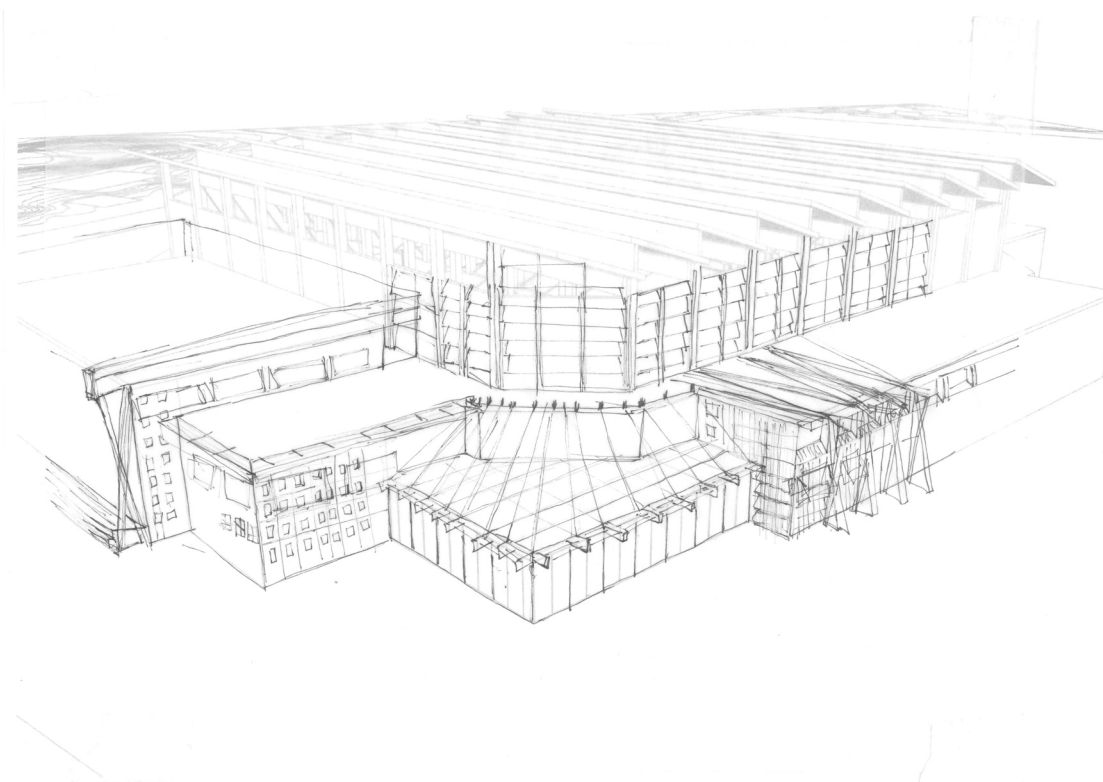
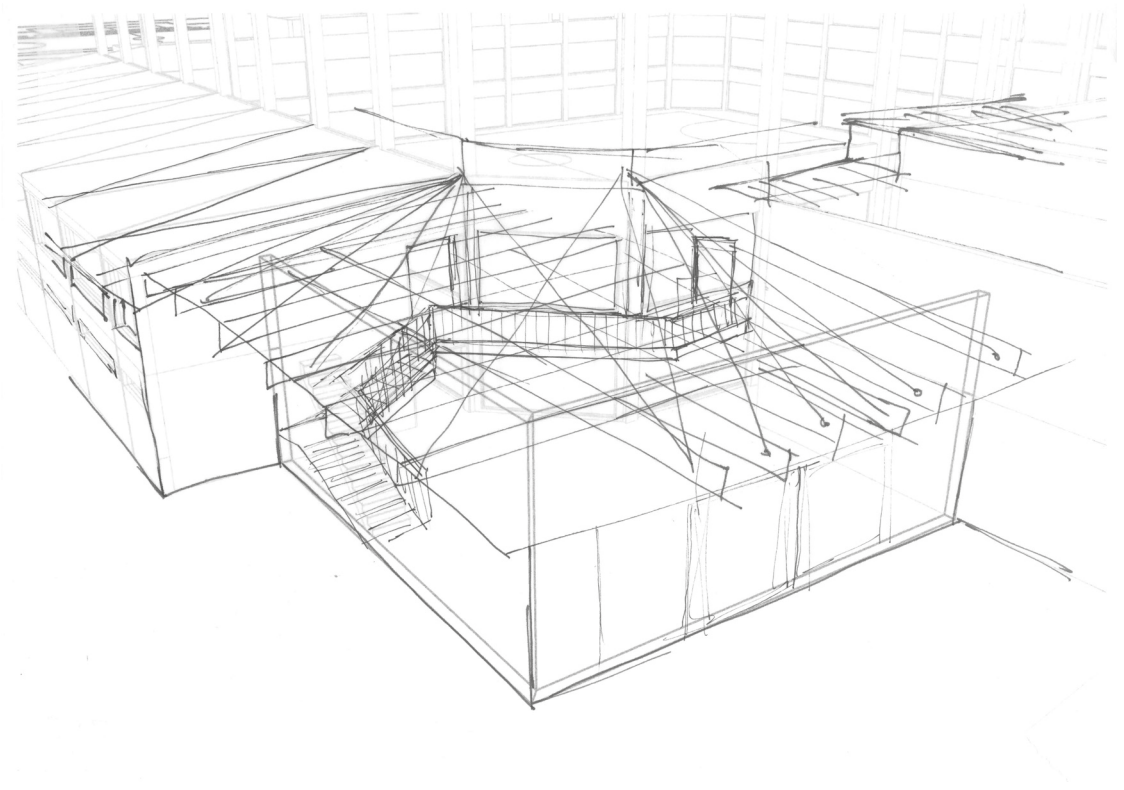
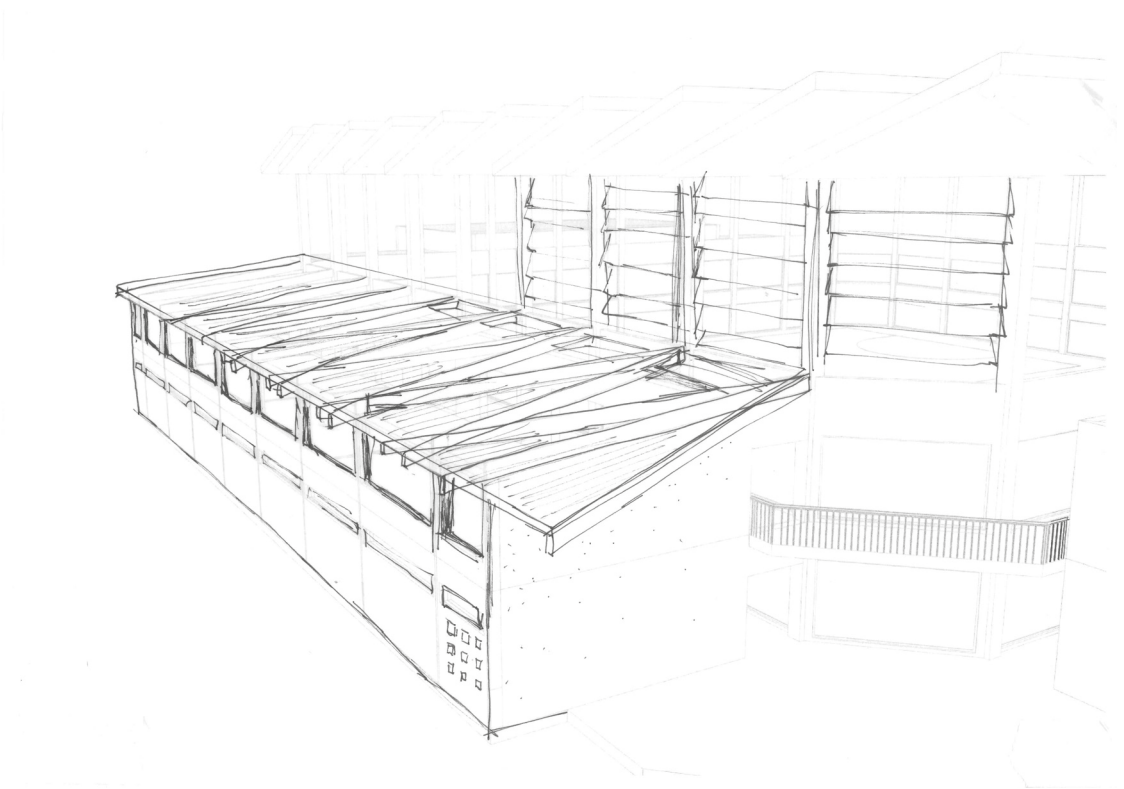


Figure 17 (Gallery). Early sketches of volumes.



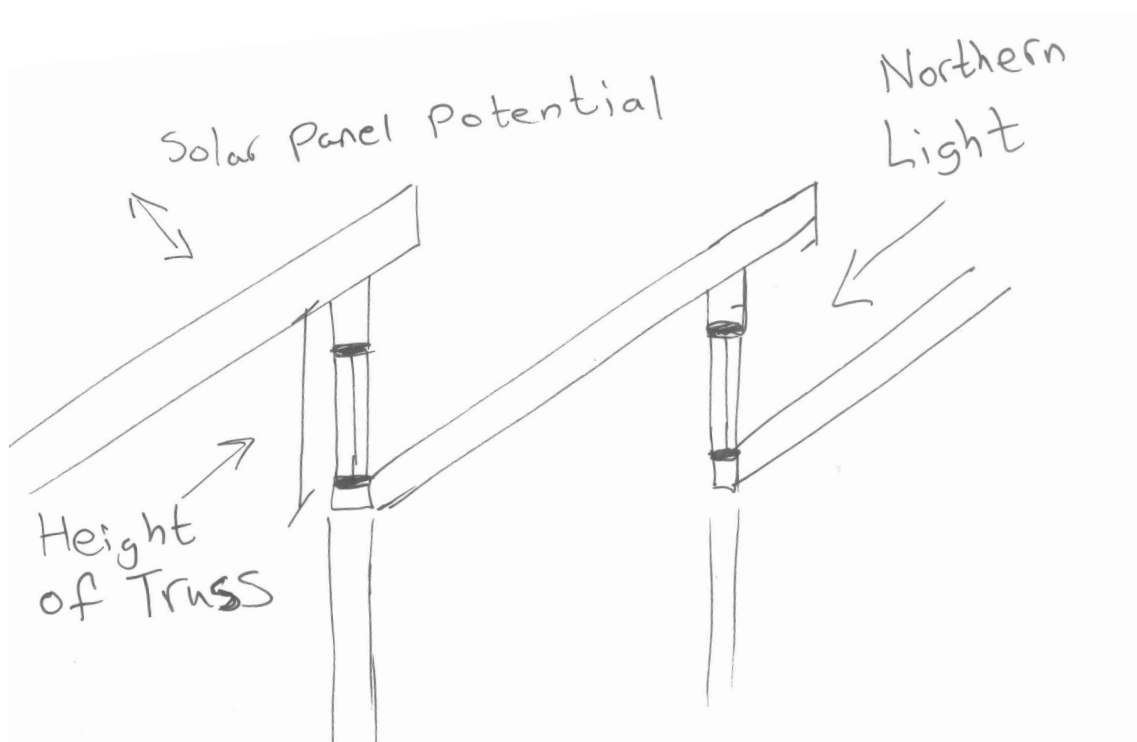


Figure 18. Design choice for Sports hall roof

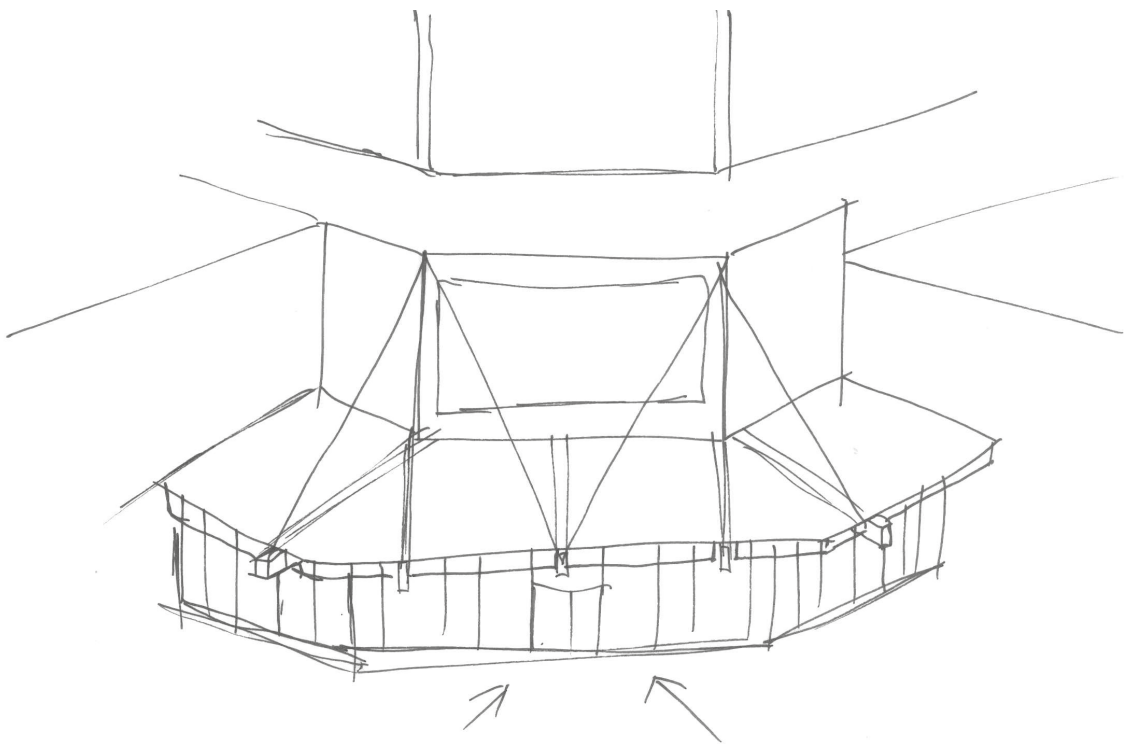


Figure 19. Design choice for Entrance

Presentation of final design

The final design became a result of the investigation done on structure, site analysis and a functional space programme. By merging the findings in all of the areas, the shape of the building became prominent that it accommodates all the terms that are put on the site.

The final design is a sports hall that is surrounded by functions that support and extend the sports hall's function.

Since the plot can be accessed from many directions, the entries to the main building were put in the corners.

The sports hall supports two full-sized 20x40 (m) sized sports hall and can arrange a bigger event where a centered area of 20x40 is placed in the middle. In connection to that, stands can be extended into the hall to allow seating possibility for the public.

The choice of material for the sports hall is timber. Timber was chosen both from an experimental point of view but also in alignment with the current goals regarding sustainability.

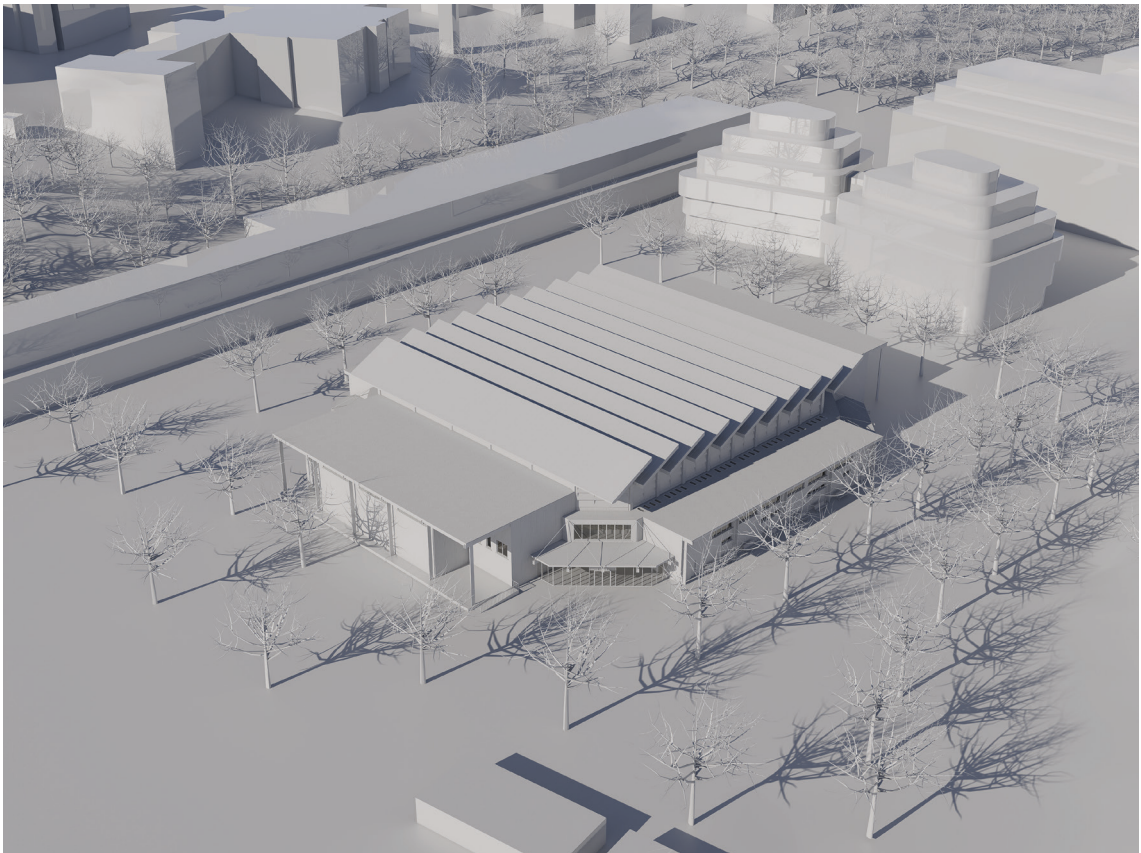
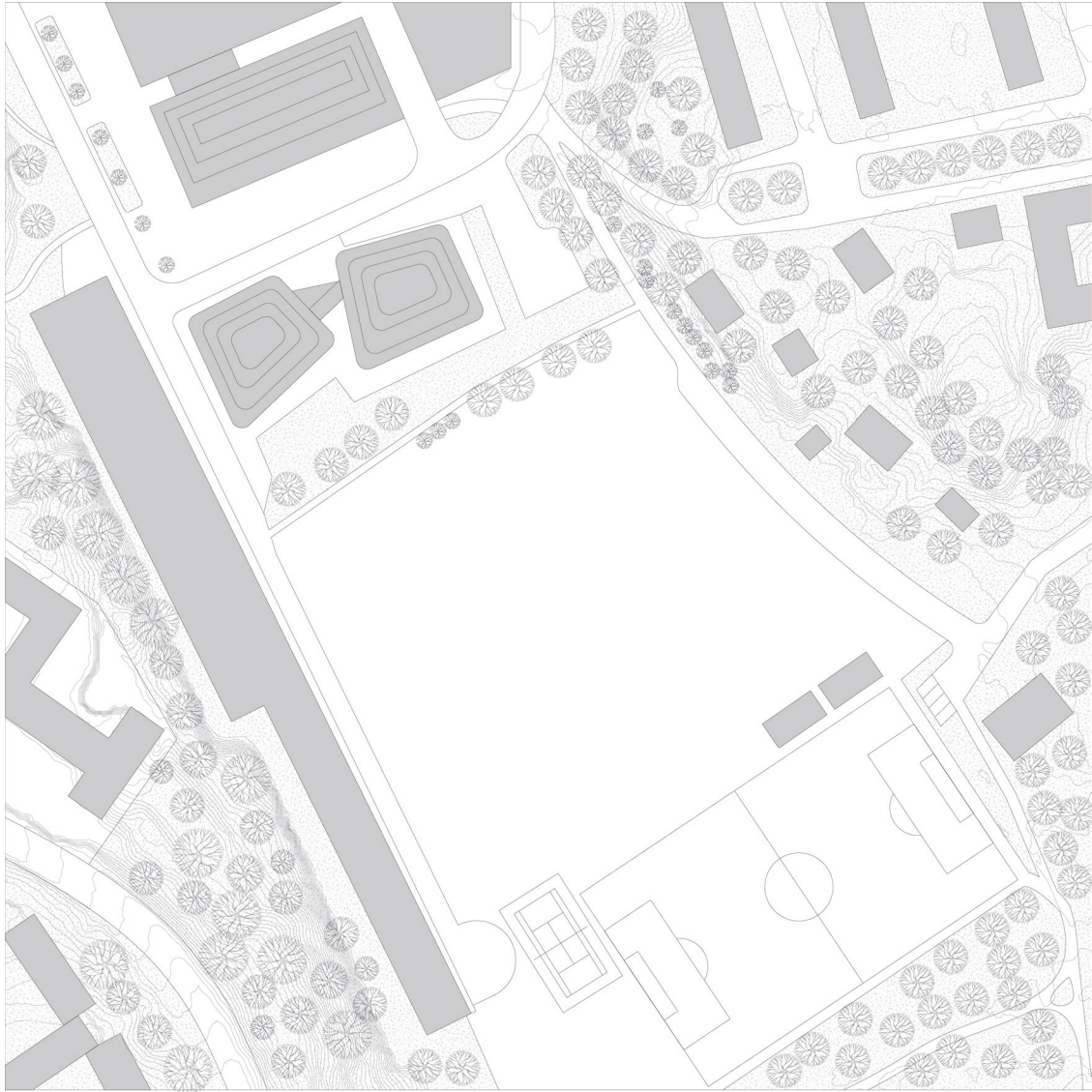
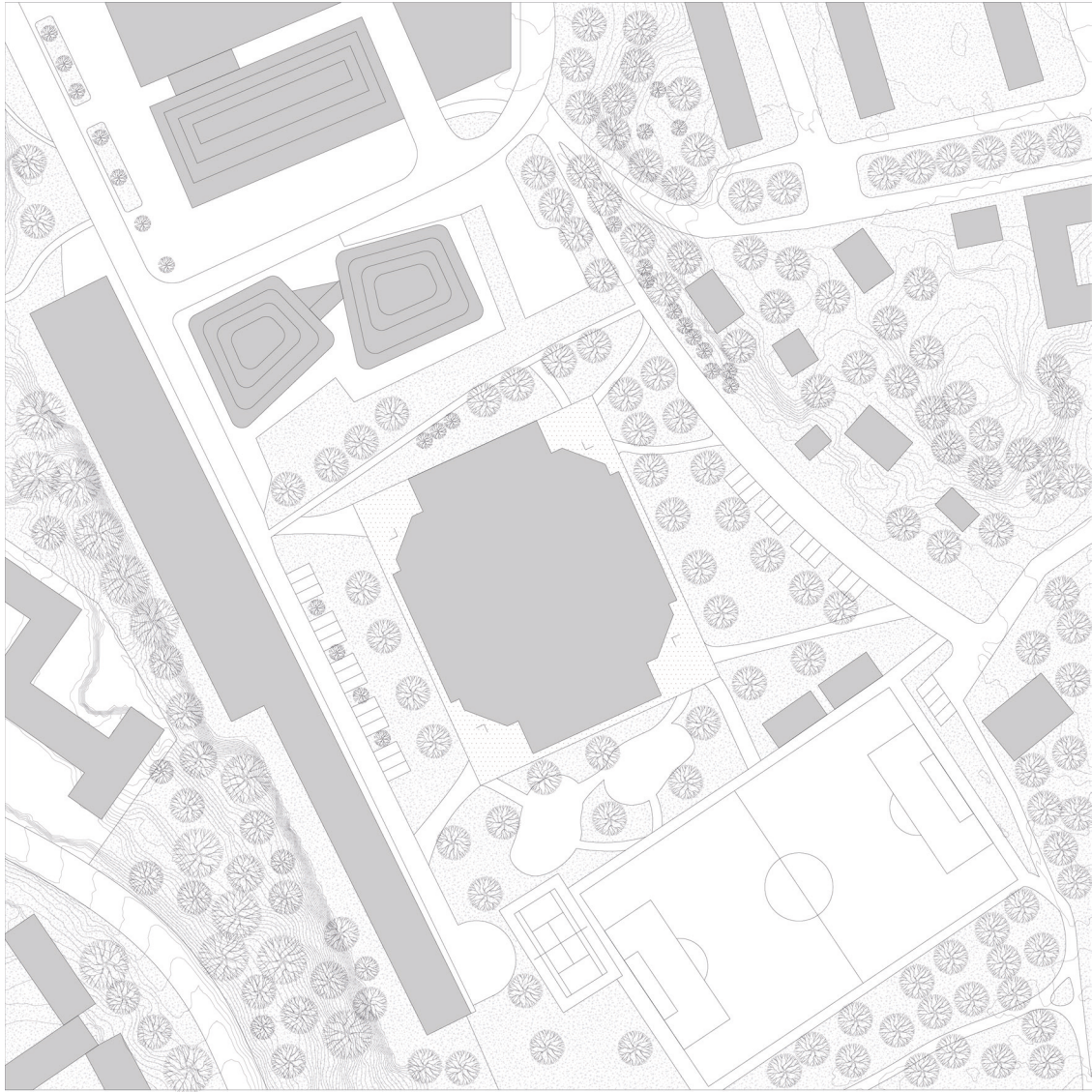


Figure 20. View on site from Southeast (1:500)



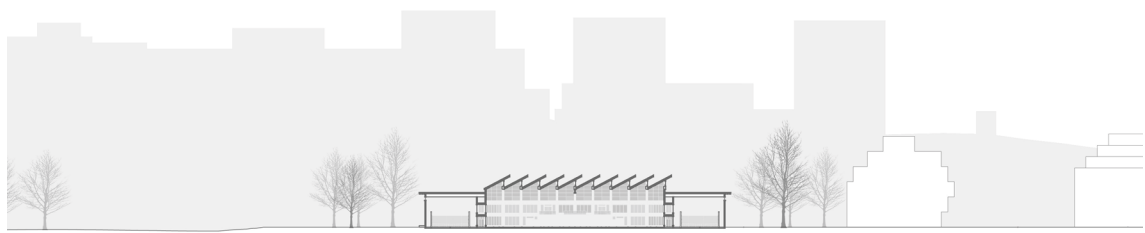
1:2000 100 m

Figure 21. Kept and moved areas on the sites



1:2000 100 m

Figure 22. Added areas and building



1:2000 100 m

Figure 23. Landscape section A

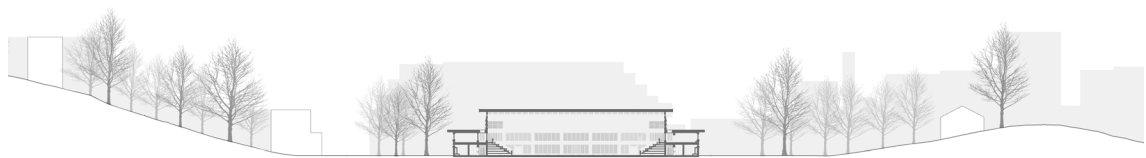


Figure 24. Landscape section B

Main material

1. Foyer
2. Main hall
3. Changing room
4. Café
5. Padel court
6. Reception office
7. Cleaning room
8. Equipment storage
9. WC
10. HWC
11. HVAC room

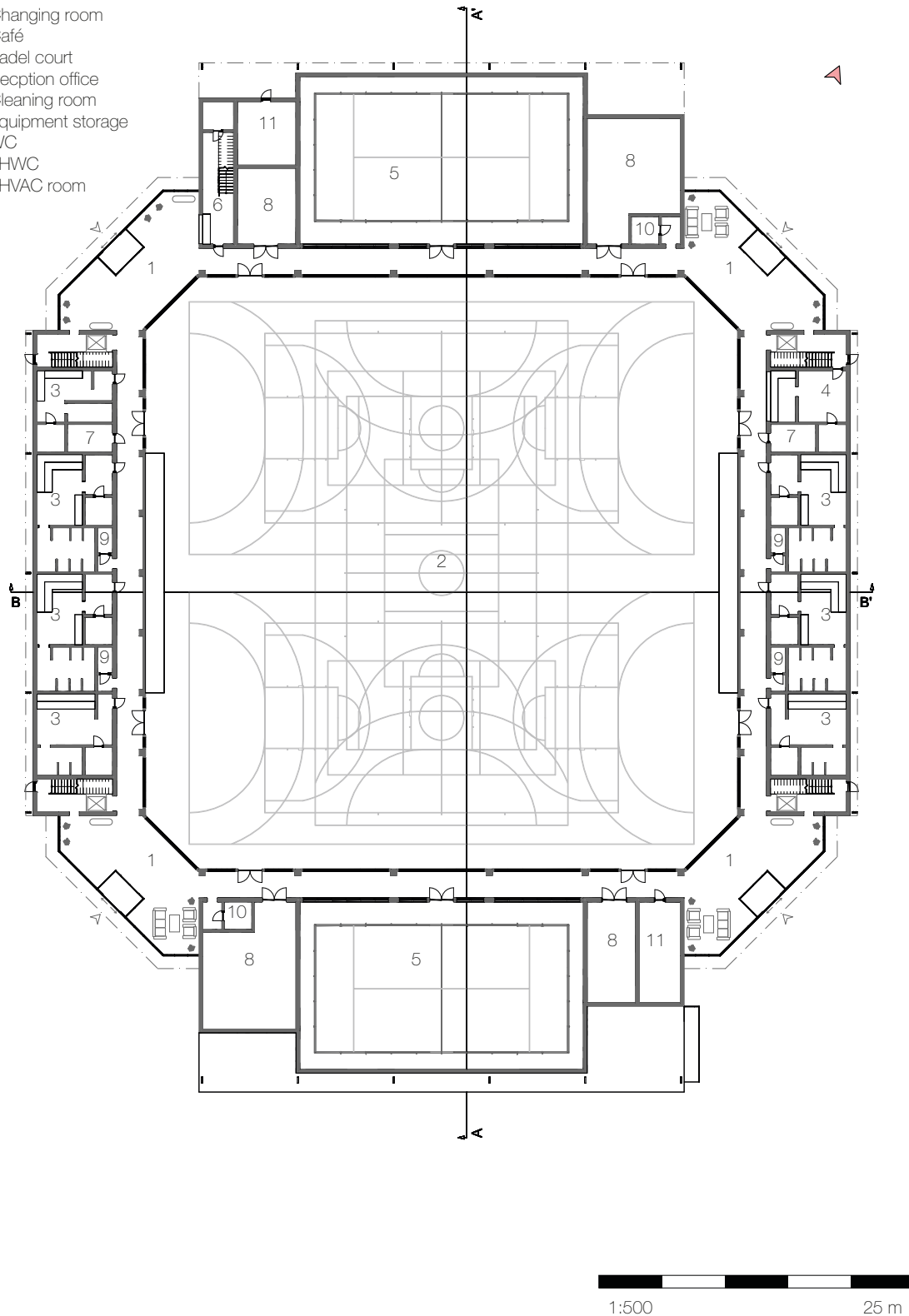


Figure 25. Entrance floor (1:500)

- 12. Student Hub
- 13. Sports lab
- 14. Study rooms
- 15. Reception office
- 16. WC units

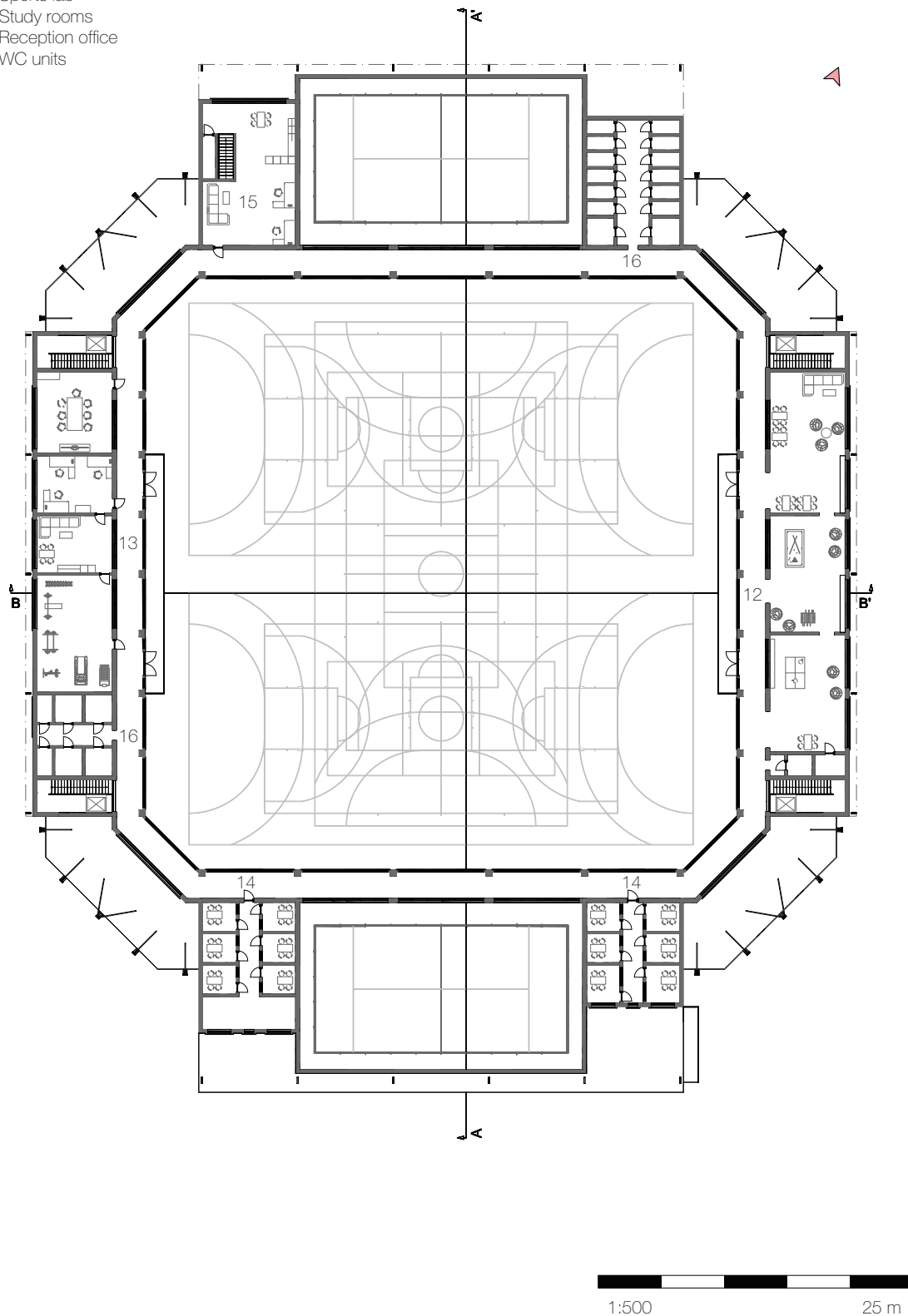


Figure 26. Floor 2 (1:500)

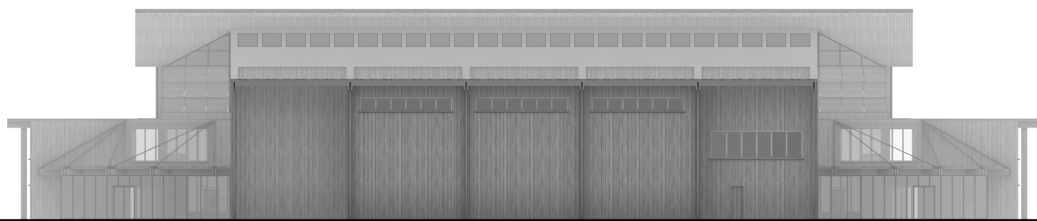


Figure 27 (Top). East Facade
Figure 28 (Bottom). North Facade



Figure 29 (Top). West Facade
Figure 30 (Bottom). South Facade

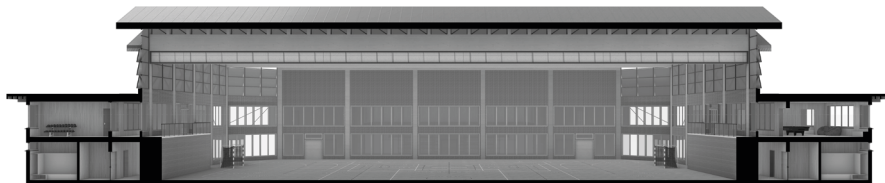
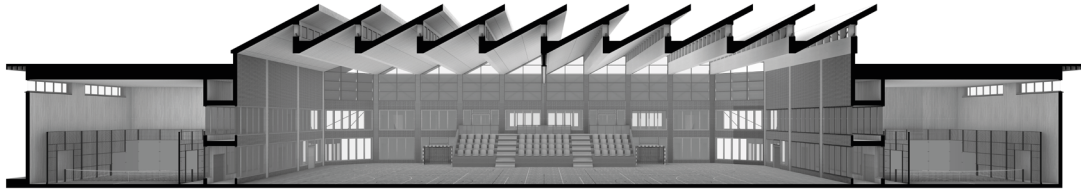


Figure 31 (Top). Section A
Figure 32 (Top). Section B

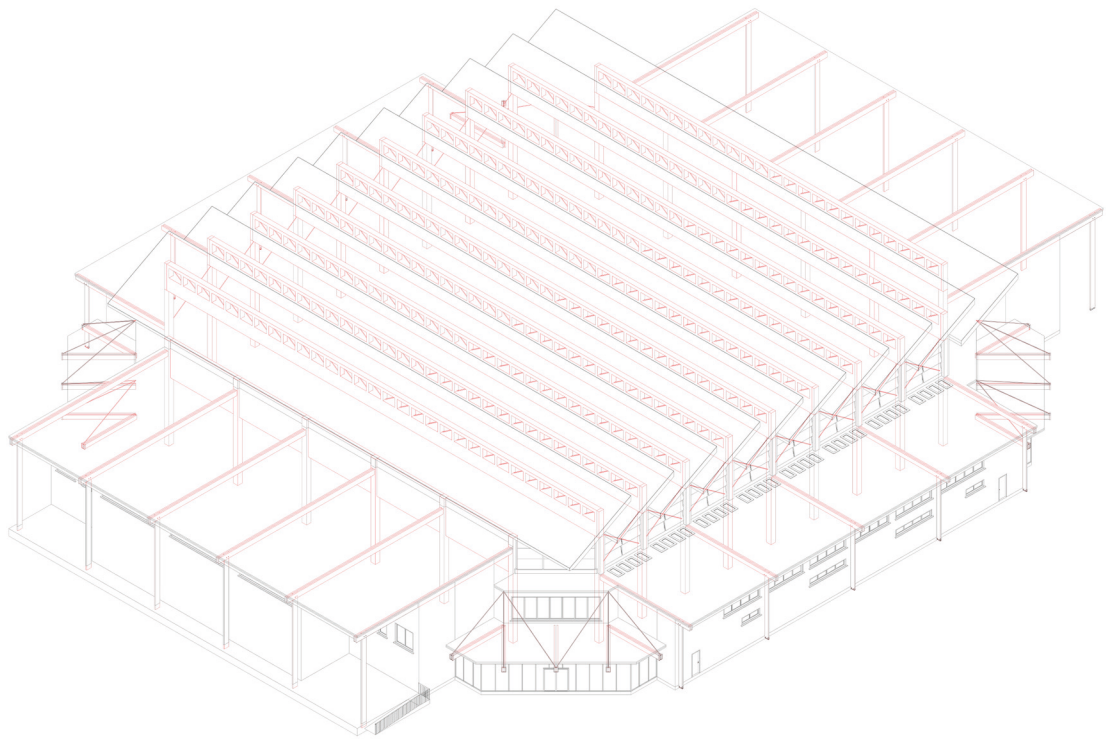


Figure 33. Axionometric view with highlighted structure



Figure 34. Southeast entrance view



Figure 35. Northeast entrance



Figure 36. Southern second floor



Figure 37. Student hub corridor



Figure 38. View from Eastern stands



Figure 39. View from south part of main hall



Figure 40. Segment of Eastern Facade

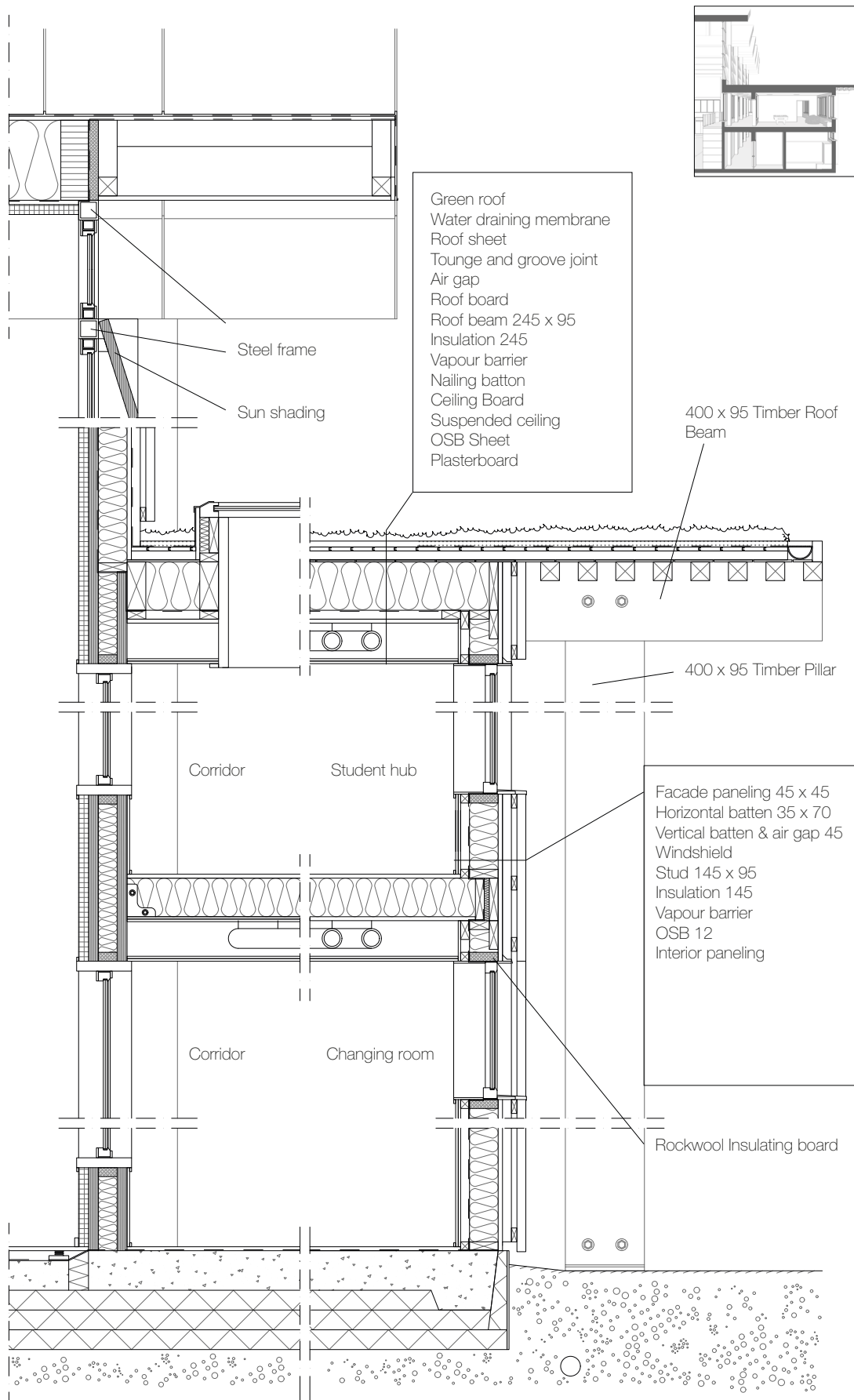


Figure 41. Detail segment of Section B (1:30)

Discussion

The project started from a curiosity of engineering and architecture, more precisely, how big of a part structures has on the overall elements that make up architecture. This was important to investigate since the potential of merging engineering knowledge and architectural ambition could be of key value, the value is in acquiring a pretty unique tool that not many architects or engineers have the chance to develop.

Often a design concept stems from something familiar in nature or society. Either by developing the way we use a building, the way we build it, or the way we experience it. Designing with this point of view in mind, one can investigate structures and explore it's multilayered solutions. Both by developing the experience and the order of space but also trying to efficiently solve the structural challenges that come with creating buildings.

The question in this thesis was "How can a tectonic approach be used to design a sports hall in Gothenburg?"

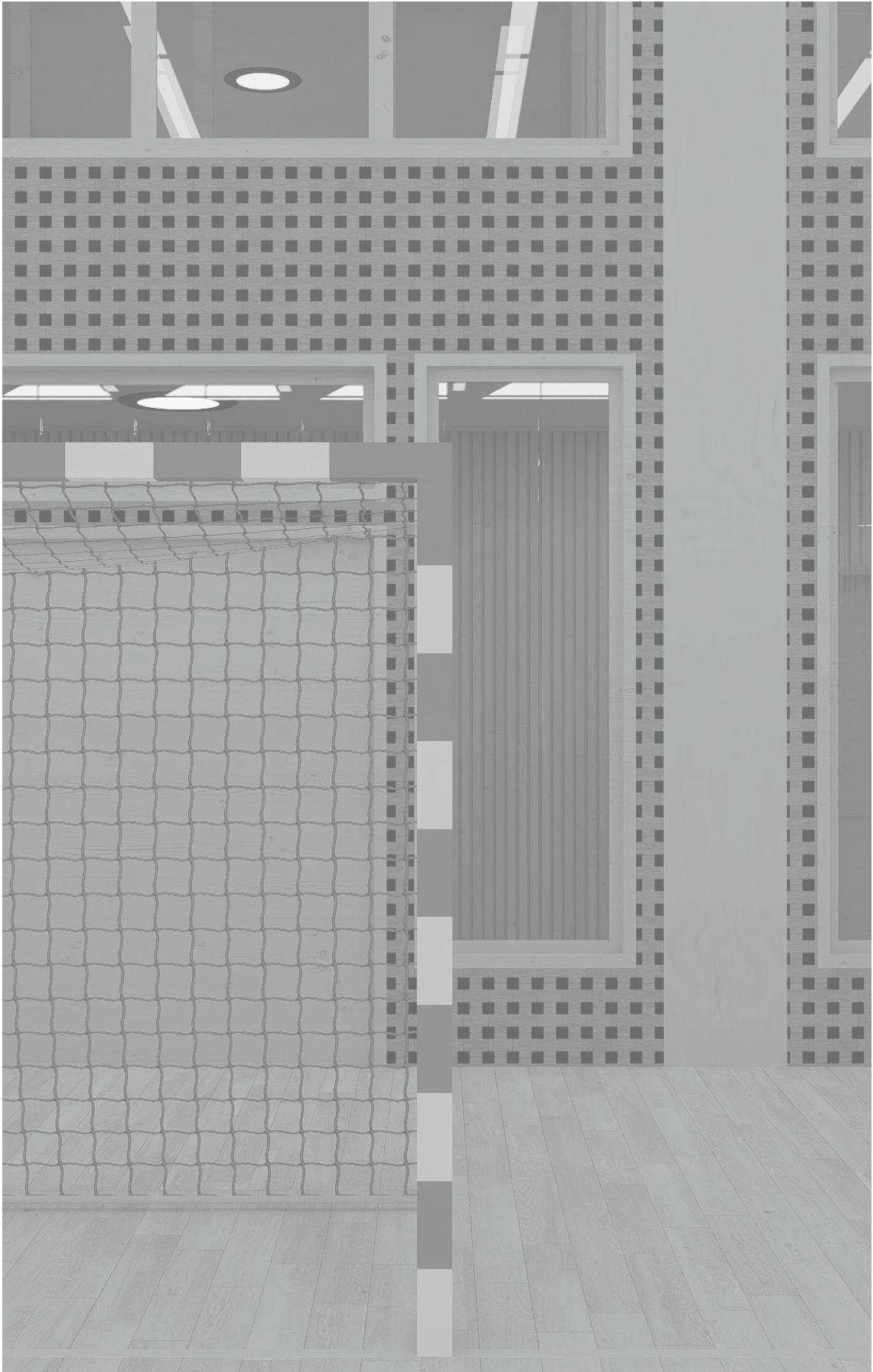
By looking at the proposal that was designed in this thesis there was some discoveries made about structures and its application in architecture. Firstly the research revolved on how structures are used for sports halls. Although this step is crucial, the time spent on this part could have been of more significance, to ensure a more solid base for the investigation.

The second part of the investigation was applying a concept for the space and experience of the sports hall that would be designed. In this case the site was close to Chalmers University and the programme stemmed from a vision from the Chalmers Union, that later had to be narrowed down to a more feasible size in order to allow for a proper investigation for a master thesis. This in hindsight did create a bit of friction between the design and the ambition I had on this project, and a better way to do this would have been to create a programme from scratch that would allow for a better discussion around the theme of structures.

Before diving into the structural analysis of the project, there was an ambition to use structural elements to create an experience where structures invoke curiosity about the building and grabbing attention into it's way of working and it's structural logic. Later while investigating structures I found out that a lot more technical knowledge was needed in order to be able to manipulate the elements in said manner.

In order to make use of what was had at hand, I had to use structures in a different way in order to affect the architectural space of the sports hall. The structural complexity was toned down and instead of using the structures as a main element of interest, it was used to apply a hierarchy of space in and around the building. By applying different degrees of exposure and complexity on the structure, I could inform about the buildings different parts. This also created a discovery and a different understanding to what impact structures have on architecture, but most importantly what it becomes when structure in contrast gets toned down in order to create a certain balance. This enriches the discussion into another branch where structure's potential is in it's absence as much as it is in it's presence.

In conclusion, structure has the potential to affect many aspects of architectural design but in order to maintain control over it's impact, one has to understand both the technical parts and the spatial experience that it delivers in the different scales and level of exposure.



Student background

After acquiring a bachelor's degree in Architecture and engineering, an interest towards both of the fields invoked questions about what role engineering could have in architecture, and if there is a benefit of being able to manipulate structures in order to elevate an architect's intention into the design. Throughout the studies in the architectural master program I try to merge the two fields. The studios I have been participating in have not been adapted to this kind of interplay, therefore the chance to do this as a master thesis is a single excellent chance for such an experiment. After acquiring a degree in Architecture the goal is to extend my knowledge into the field of engineering and acquire a degree in Civil engineering in order to extend my capabilities as an architect.

References / bibliography

Beim, A., & Bech-Danielsen, C. (Eds). (2014). Towards an ecology of tectonics: The need for rethinking construction in architecture. Menges.

Charleson, A. W. (2005). Structure as architecture: A source book for architects and structural engineers. Architectural press.

Ciambella, J., Ranzi, G., & Romeo, F. (2024). The Pier Luigi Nervi's concrete structure of Palazzetto dello Sport: Modeling and dynamic characterization. Structural Concrete, suco.202400320. <https://doi.org/10.1002/suco.202400320>

Hanington, B. M., & Martin, B. (2019). Universal Methods of Design: 125 Ways to Research Complex Problems, Develop Innovative Ideas, and Design Effective Solutions. Rockport Publishers.

KÅREN 2040. (n.d.). KÅREN 2040. Retrieved 7 October 2025, from <https://www.karen2040.se>

Meissner, I., Möller, E., & Otto, F. (2017). Frei Otto: Forschen, bauen, inspirieren = Frei Otto: a life of research, construction and inspiration (2. Auflage). Edition Detail.

Muttoni, A., & Piccolo, S. (2011). The art of structures: Introduction to the functioning of structures in architecture. EPFL press Routledge.

Nybyggnad och upprustning av idrottshallar. (n.d.). Göteborgs Stad. Retrieved 6 October 2025, from <https://goteborg.se/wps/portal?uri=gbglnk%3a2022101415257461>

Popovič Larsen, O., Popovič Larsen, O., & Tyas, A. (2003). Conceptual structural design: Bridging the gap between architects and engineers. Thomas Telford.

Saint, A. (2007). Architect and engineer: A study in sibling rivalry. Yale university press.

Salvadori, M. (1990). The Art of construction: Projects and principles for beginning engineers and architects (3. ed). Chicago Review Pr.

Sandaker, B. N. (2008). On span and space: Exploring structures in architecture. Routledge.

Schwartz, C. (2017). Introducing architectural tectonics: Exploring the intersection of design and construction. Routledge. <https://doi.org/10.4324/9781315735467>

Vitruvius. (2009). Om arkitektur: Tio böcker (Rev. pocketutg.). Dymling.

Figure 3. Sebastian Delmont. (2012). Balanced stones (photo). Flickr. <https://www.flickr.com/photos/49503029779@N01/8287529748>

Figure 4. Absurdicus. (2014). Ball stuck in the ceiling of Palazzetto dello sport (photo). Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Palazzetto_dello_Sport.JPG

Figure 6. HerRobin (2024). Aerial view of Palazzetto dello sport (photo). Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Le_Palazzetto_dello_Sport_en_vue_a%C3%A9rienne.png

Figure 7. Dario Crespi (2025). Inside of Palazzetto dello sport (photo). Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Wiki-concrete_editathon_at_MAXXI,_Rome,_June_2025_57.jpg

Figure 8. Romain Laprade (2024). Photos of Gymnase Jules Ladoumégue (Photo gallery). Instagram. <https://www.instagram.com/romainlaprade/>

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